

Dichotic Word Recognition and the Neighborhood Activation Model
of Speech Perception

A Senior Honors Thesis

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by

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ABSTRACT

Dichotic word recognition was measured using monosyllabic words paired according to lexical categories based on the Neighborhood Activation Model (NAM) of speech perception. Differences in lexical difficulty of the stimuli were investigated to determine their affect on dichotic word recognition performance. Twelve right-handed young adults with normal hearing participated in the present study. The stimuli consisted of the Northwestern University Auditory Test Number 6 (NU-6) monosyllabic word list paired dichotically according to NAM lexical categories (i.e., four word categories based on word frequency and density). Dichotic word recognition was measured in three response conditions: 1) free recall (repeat both words in any order), 2) directed right (repeat word presented to right ear first), and 3) directed left (repeat word presented to left ear first). Dichotic word recognition scores revealed a right ear advantage of 2.67% for free recall and 4.75% for directed right dichotic response conditions. The directed left dichotic response condition revealed a left ear advantage of 2.25%. For all three response conditions, word pairings across NAM categories yielded similar recognition performance. Results correspond to previous studies, further supporting the importance of brain dominance and lexical factors on word recognition performance in dichotic listening.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Dichotic Listening

The term “dichotic listening” was born out of the Broadbent technique in 1954, where three-pair digits were presented simultaneously through earphones, one in the right ear and one in the left ear for three pairs in a row (Broadbent, 1954). Dichotic listening is a diagnostic tool that today involves subjects listening to two competing messages that are never the same at the two ears, but vary in their similarity to one another (Noffsinger, Martinez, & Wilson, 1994). The competing signals can range from the less-difficult pairing of broadband noise with speech to the more-difficult pairing of two lexically similar speech signals (Carter & Wilson, 2001; Roup, Wiley, & Wilson, 2006). The speech stimuli used in dichotic listening includes digits, words, sentences, or nonsense syllables (Noffsinger, et al., 1994; Roup, et al., 2006). Diagnostic use of dichotic listening includes testing hemispheric dominance, speech recognition, and auditory processing in adults and children (Findlen & Roup, in review). Results of dichotic listening tests are useful in possibly revealing language and learning disabilities (Findlen & Roup, in review).

Brain Hemisphere Dominance

Brain hemisphere dominance in subjects plays an important role in recognition performance of dichotic stimuli (Kimura, 1961b). Kimura suggested that the left hemisphere of the brain was predominantly responsible for speech

perception (Kimura, 1961b). Kimura administered dichotic word recognition testing on subjects with brain lesions and investigated the affect of brain hemisphere dominance as well as subsequent brain impairment to specific stimuli that varied with laterality of the lesion (Kimura, 1961b). The procedures used by Kimura were free recall simultaneous presentation of digits, staggered onset presentation alternating condition, and staggered onset presentation all in one ear and then in the other (Kimura, 1961b). Results of this experiment showed that patients with lesions of the left temporal lobe have poorer performance than patients with lesions of the right temporal lobe. And subjects with lesions on the left hemisphere of their brain had overall impairment in digit recognition performance on the dichotic listening task, suggesting that the left temporal lobe is specialized for verbal material (Kimura, 1961b).

Kimura also investigated if contralateral (opposite side) connections from ear to cortex were stronger than ipsilateral (same side) connections (Kimura, 1961b). Kimura suggested that lesions on the temporal lobe of either side of the brain impair the perception of digits arriving at the contralateral ear (Kimura, 1961b). Kimura also suggested that when a brain lesion affects the performance of its contralateral ear, the ipsilateral connection is used – which Kimura suggests is a weaker connection and may have trouble allowing the brain to recognize distorted stimuli and/or stimuli with additional noise (Kimura, 1961b). Kimura's experiment demonstrated contralateral pathways being affected during dichotic listening, where contralateral and ipsilateral pathways are competing (Kimura, 1961b). Results from this experiment showed that unilateral lesions on

either side of the brain impaired recognition of stimuli arriving at the contralateral ear (Kimura, 1961b). Kimura therefore suggested that there is an overlap at some point between contralateral and ipsilateral pathways, and at one point the contralateral pathways dominate (Kimura, 1961b).

Kimura's test results suggest that contralateral connections from ear to cortex predominate over ipsilateral connections during dichotic listening, and that auditory processing of speech takes place in the left hemisphere of the brain (Kimura, 1961b). Kimura studied brain hemisphere dominance in speech perception further by comparing dichotic listening task results of left hemisphere dominant subjects with right hemisphere dominant subjects (Kimura, 1961a). The results of this study further suggest that contralateral connections from ear to cortex predominate over ipsilateral connections (Kimura, 1961a). For those subjects with left hemisphere dominance, speech recognition performance was more efficient in the right ear, while for those subjects with right hemisphere dominance, speech recognition performance was more efficient in the left ear (Kimura, 1961a).

Studdert-Kennedy and Shankweiler (1970) concluded that both brain hemispheres were capable of speech perception, but only the dominant hemisphere could pick out specific linguistic features of speech. Kimura (1966) also tested the age at which cerebral dominance first makes an appearance in speech recognition, and results showed that a left hemisphere dominance for speech perception can be present as early as age four.

Listeners are typically better at recognizing speech presented to the right ear during dichotic listening tasks, which is known as a right-ear advantage (REA) (Carter & Wilson, 2001; Kimura, 1961a, b; Kimura, 1966; Noffsinger, et al., 1994; Roup, et al., 2006; Studdert-Kennedy & Shankweiler, 1970). Also, the responsibility for speech perception is suggested to lie within the left hemisphere of the brain (Kimura, 1961a, b; Kimura, 1966; Noffsinger, et al., 1994; Studdert-Kennedy & Shankweiler, 1970). Kimura suggests that contralateral pathways are stronger than ipsilateral pathways in the brain, therefore if the left hemisphere of the brain is responsible for speech perception – its contralateral ear (the right ear) should have a better performance than the left ear in recognizing speech stimuli (Kimura, 1961b). The REA for dichotic listening is generally explained in two ways. The structural theory describes ear advantages as being the result of anatomical and physiological characteristics of the auditory system (Kimura, 1961a; Kimura, 1961b; Kimura, 1966). Kimura explained that contralateral pathways have a greater number of fibers than ipsilateral pathways, and that the two pathways overlap – at which point the contralateral pathways could take over any impulses that were arriving along the ipsilateral pathways (Kimura, 1966). The combination of a greater number of fibers and the ability to overtake impulses at a point of overlap explains how contralateral messages may produce an enhanced advantage in the ear opposite the dominant hemisphere (Kimura, 1966).

Conversely, the attentional theory describes ear advantages as being the result of speech stimuli priming the brain to attend to different sounds in different

ways (Kinsbourne, 1970). Kinsbourne (1970) suggested that the left hemisphere is primed for speech stimuli and that the right hemisphere is primed for nonspeech stimuli, and the brain's attention for each stimulus is shifted to the opposite ear of the side of the brain that is primed because contralateral pathways are stronger than ipsilateral pathways. Therefore, when different speech stimuli are coming in to each ear at the same time, as in dichotic listening, the left hemisphere is primed and the brain's attention is focused on the right ear – allowing the right ear to perform better than the left ear in word recognition – which results in a right-ear advantage (Kinsbourne, 1970). Both the structural and attentional theory suggest a contralateral pathway advantage, so therefore the REA is most likely explained by a combination of these two theories.

Free Recall and Directed-Attention Conditions Response

Dichotic speech recognition performance is typically administered in three ways. Free recall instructs the subject to recall both stimuli regardless of order, while directed-attention right and directed-attention left instruct the subject to attend to a specific ear while listening (Roup, et al., 2006). While no cueing is provided for listeners before free recall, listeners are cued to direct their attention a certain way before directed-attention right and left (Roup, et al., 2006).

Directed-attention right and left can be administered in different ways. The most common response paradigm for directed-attention is to instruct the listener to focus only on the stimulus coming into the cued ear, while ignoring the stimulus

coming into the non-cued ear (Roup, et al., 2006). A second response paradigm for directed-attention is to instruct the listener to focus on the cued ear, but recall the stimuli from both the cued ear and non-cued ear while also providing the stimuli in the correct order – the signal from the cued ear first, followed by the signal from the non-cued ear (Roup et al., 2006). Both of these response paradigms for directed-attention result in ear advantages in the direction of cueing, so despite which paradigm is used, directed-attention affects the listener's direction of ear advantage (Roup et al., 2006). Free recall and directed-attention right generally result in an REA in most young and older adult listeners, while directed-attention left generally results in a left-ear advantage or a small REA in most young and older adult listeners (Roup et al., 2006).

Dichotic Word Recognition Performance and Handedness

Specific characteristics of subjects may contribute to their recognition performance in dichotic listening. Handedness of subjects has an affect; right-handed subjects tend to yield a stronger right-ear advantage than left-handed subjects (Wilson & Leigh, 1996). A study by Wilson and Leigh (1996) demonstrated three relationships among right-handed and left-handed subjects according to stimuli recognition performance during dichotic listening. Right-handed subjects had better identification performances on materials presented to the right ear than materials presented to the left ear, left-handed subjects had a smaller REA in comparison to right-handed subjects as well as more inter-subject variability than right-handed subjects, and left-handed subjects had better

identification performances on materials presented to the right ear than materials presented to the left ear – but by a much smaller percent than right-handed subjects (Wilson & Leigh, 1996).

To obtain an accurate measure of handedness for subjects, an inventory developed by Oldfield is available that examines subjects regarding sex, cultural, and socio-economic factors (Oldfield, 1971). The questions on this inventory address which hand the subject uses to write, draw, throw, use scissors, toothbrush, knife, spoon, broom, match striking, and box opening (Oldfield, 1971). Incidence of left-handed subjects is higher among males than among females (Oldfield, 1971). To avoid the issue of handedness possibly skewing results in dichotic word recognition performance, many studies use only right-handed subjects (Carter & Wilson, 2001; Findlen & Roup, in review; Roup, et al., 2006; Studdert-Kennedy & Shankweiler, 1970; Wilson & Jaffe, 1996).

Dichotic Word Recognition Performance and Age / Hearing Loss

The age of subjects and their subsequent levels of hearing (younger subjects with normal hearing versus older subjects with hearing loss) also have an affect on dichotic listening. Younger subjects tend to yield a smaller right-ear advantage but have better word recognition performance than older subjects (Carter & Wilson, 2001; Roup et al., 2006; Wilson & Jaffe, 1996). In a study done by Wilson and Jaffe (1996), results demonstrated that dichotic stimuli recognition performance was worse for older adults with a hearing loss than for younger adults with normal hearing as the complexity of the stimuli increased,

and overall word recognition performance was much better for the young adults than for the older adults (Wilson & Jaffe, 1996).

Other studies concluded that older subjects with a hearing loss had lower overall performance and a larger REA than younger subjects with normal hearing during dichotic listening tasks, suggesting the presence of a left-ear disadvantage in older adults with a hearing impairment (Carter & Wilson, 2001; Roup, et al., 2006).

Dichotic Word Recognition Performance and Type of Stimuli

The type of stimuli used in dichotic listening can also have an effect on word recognition performance (Balota et al., 2007; Carter & Wilson, 2001; Dirks, et al., 2001; Findlen & Roup, in review; Luce & Pisoni, 1998; Noffsinger, et al., 1994; Studdert-Kennedy & Shankweiler, 1970; Takayanagi, et al., 2002; Wilson & Jaffe, 1996). For example, as the number of pairs of digits presented dichotically increases from one to four, recognition performance is largely decreased (Wilson & Jaffe, 1996). A study by Noffsinger et al. (1994) tested word recognition performance with digits, sentences, and nonsense syllables. Subjects in this study had high performance levels for digits and sentences, but more difficulty recognizing nonsense syllables (Noffsinger et al., 1994). These results displayed a range of difficulty in stimuli for clinicians to use – with nonsense syllables being the most difficult for subjects to recognize in testing and digits and sentences being easier (Noffsinger, et al., 1994). Findlen and Roup (in review) also discovered that word recognition performance levels

decreased for nonsense syllables in comparison to CVC words. Furthermore, testing of nonsense syllables in dichotic pairs that differed by only one phoneme showed that a significant REA existed for differences in initial and final stop consonants, but not for vowels (Studdert-Kennedy & Shankweiler, 1970).

Dichotic Word Recognition Performance and Lexical Effects

Concerning actual words as opposed to nonsense syllables, divisions between lexically “easy” words and lexically “hard” words demonstrate that “easy” words are identified correctly more often than “hard” words in dichotic word recognition testing (Carter & Wilson, 2001). Making changes in the lexical difficulty of stimuli for speech recognition testing appears to affect every subject, regardless of handedness, age, or level of hearing (Takayanagi, et al., 2002). Results from testing stimuli that has been modified lexically or by level of difficulty suggest that lexical factors should be included in the development of speech recognition tests (Balota et al., 2007; Carter & Wilson, 2001; Dirks, et al., 2001; Findlen & Roup, in review; Luce & Pisoni, 1998; Noffsinger, et al., 1994; Studdert-Kennedy & Shankweiler, 1970; Takayanagi, et al., 2002; Wilson & Jaffe, 1996).

The Neighborhood Activation Model

In 1998, Luce and Pisoni developed the Neighborhood Activation Model (NAM) of speech perception. This model works with the structural organization of spoken words in the mental lexicon (Luce & Pisoni, 1998) and can be used to

develop more effective stimuli for dichotic word recognition testing. This model is what aides in making decisions between labeling a word as lexically “easy” or lexically “hard.” In the design of the NAM, similarity neighborhoods (a list of words that are phonetically similar to a given stimulus word) were computed for 20,000 word transcriptions (Luce & Pisoni, 1998). The variables of interest in computation were the number of words occurring in each neighborhood, the degree of phonetic similarity among words, and frequencies of occurrence of these words in their language (Luce & Pisoni, 1998).

Three word recognition performance tasks were tested – the perceptual identification of words in noise, the speed of auditory lexical decision, and the accuracy of word naming (Luce & Pisoni, 1998). Results from these tests indicated that the number and nature of words in a similarity neighborhood affected a subject’s speed and accuracy of word recognition (Luce & Pisoni, 1998). Luce’s choice rule combined stimulus word intelligibility, neighborhood confusability, and frequency into a single expression, leading to the development of the neighborhood probability rule which predicts word recognition performance of subjects (Luce & Pisoni, 1998).

This evidence pointing towards the importance of lexical factors in speech recognition testing led to the proposition of a model of auditory word recognition – the Neighborhood Activation Model (Luce & Pisoni, 1998). Words with low density neighborhoods, low frequency neighbors, and high word frequencies were shown to be the “easiest” to identify. In short, the NAM describes effects of similarity neighborhood structure on the process of discriminating among

acoustic-phonetic representations of words in memory – the results of which affect word recognition performance levels (Luce & Pisoni, 1998).

Use of the NAM in Dichotic Listening Tasks

The NAM has been used in dichotic listening tasks successfully and aides in yielding more reliable test results (Carter & Wilson, 2001; Dirks, et al., 2001; Findlen & Roup, in review; Takayanagi, et al., 2002). The pairings of dichotic stimuli for nonsense syllables and CVC words according to the NAM revealed significant differences in word recognition performance (Findlen & Roup, in review). For example, the three factors of word frequency, neighborhood density, and neighborhood frequency in the NAM can mark a degree of lexical difficulty for a specific target stimulus, and it has been suggested that recognition performance in listeners is worse when the lexical difficulty of the stimuli increases (Dirks, et al., 2001). Therefore, lexical difficulty of a stimulus can be explained by the NAM, allowing poor recognition performance on that stimulus by a subject to be explained as well. Word recognition performance differences also existed when the NAM was applied to words alone – making them lexically “easy” or lexically “hard” (Carter & Wilson, 2001). Word lists shaped and divided by the NAM were tested in quiet and in speech-shaped noise with subjects that had a hearing loss and revealed that the NAM’s predicted results of words with low density neighborhoods, low frequency neighbors, and high word frequencies of being the “easiest” to identify were true (Dirks, et al., 2001). Applying the NAM to words tested on native and non-native listeners with normal and impaired

hearing resulted in a higher level of difficulty in word recognition performance for all subjects, proving further the importance of lexical factors in speech recognition testing (Takayanagi, et al., 2002).

The purpose of this research project is to update lexical factors of the NU-6 word list using the Neighborhood Activation Model and test the updated list on a group of subjects. This study will investigate if changes in lexical information based on the Neighborhood Activation Model affects dichotic word recognition performance in young adults with normal hearing.

CHAPTER 2

METHODS

Subjects

Twelve young adults were recruited from the Ohio State University student population to participate in the present study. The subjects included two males and ten females between the ages of 19 and 22 years (mean = 21 years). All subjects were right-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971). Left-handed individuals have greater variability in dichotic listening tasks and were therefore excluded from the study. The Edinburgh Handedness Inventory consists of a 10-item questionnaire that yields a quantitative handedness score. Subjects scoring ≤ 20 on the inventory were included in the study. All subjects had normal hearing defined as pure tone thresholds ≤ 20 dB HL at 250-8000 Hz. Bone conduction thresholds were within 10 dB of air conduction thresholds for 500-4000 Hz. Additional inclusion criteria for the study included: 1) normal otoscopy; 2) tympanometry within normal limits (Roup, Wiley, Safady & Stoppenbach, 1998); and 3) English as a first language.

Materials

The Northwestern University Auditory Test No. 6 (NU-6) monosyllabic word list spoken by a female speaker from the Department of Veterans Affairs compact disc (CD) Speech Recognition and Identification Materials 1.1 (VA Medical Center, Long Beach, CA, 1991) was used as the stimuli for the present study. The 200 NU-6 monosyllabic words were paired to create 100 dichotic

word pairs. The words were paired according to three specific criteria. First, the words were categorized according to the NAM (Luce & Pisoni, 1998). According to the lexical characteristics defined by the NAM, four word categories were identified based on word density and word frequency: 1) high density and high frequency, 2) high density and low frequency, 3) low density and high frequency, and 4) low density and low frequency. Second, words within each category were rank ordered based on the onset of the word relative to the carrier phrase “Say the word”. In this manner, the onsets of the words that were adjacent in the rank ordering essentially were simultaneous. And third, words with the same phonemes in the same word positions were avoided. Individual two-channel files were created for each word pair (Adobe Audition™ 1.5). These files were used to create seven randomizations (Haahr, 1998) of the 100-word pairs that were recorded on CD. Each randomization was recorded as two lists of 50-word pairs. Six of the randomizations were used as experimental word lists and the seventh was used as a practice list. A 4.5 second interstimulus interval was used.

Procedures

Dichotic word recognition was measured in three response conditions: 1) free recall, 2) directed right, and 3) directed left. In the free recall condition, the subject was instructed to recall the stimuli from both ears, in any order. In the directed right condition, the subject was instructed to recall the stimuli from both ears, repeating the word presented to the right ear first. In the directed left condition, the subject was instructed to recall the stimuli from both ears,

repeating the word presented to the left ear first. In each of the three response conditions, all 100 dichotic word pairs were presented to the listener. The listener responded verbally and the responses were recorded as correct or incorrect. No feedback was given to the subject except for encouragement and further instruction if needed to perform the listening task. Before each experimental condition, subjects were familiarized with the task with a 10-item practice list. The listener responses to the practice list were not recorded. The six randomizations of the dichotic word pairs were counter-balanced across the 12 subjects to avoid list effects. The free recall condition was presented first to all subjects. The directed right and directed left conditions were also counter-balanced in presentation order across the 12 subjects. The stimuli were presented from a CD player (Sony CE375) through a two-channel audiometer (Grason Stadler, Model 61) and presented at 50 dB HL through insert earphones (EARTone 3A). The channel through which the dichotic words were presented to the right and left ears was alternated between response conditions. All testing was conducted in a double-wall sound booth. Both the audiometer and tympanometer were calibrated according to the appropriate American National Standards Institute standards (ANSI, 1987, 2004).

CHAPTER 3

RESULTS

Descriptive Statistics

Figure 1 presents the mean dichotic word recognition scores (in percent correct) for the right ear and left ear across response conditions. As can be seen in Figure 1, the right ear had the best mean word recognition score for the directed right condition and the left ear had the best mean word recognition score for the directed left condition. Both ears had the lowest mean word recognition score for free recall. These results are consistent with previous results from Roup et al. suggesting that dichotic word recognition scores improve when the listener's response is directed, or given a listening strategy (Roup et al., 2006).

Figure 2 presents the mean ear advantages (in percent correct) across response conditions. As can be seen in Figure 2, the free recall and directed right response conditions resulted in a REA while the directed left response condition resulted in a LEA. Specifically, the REA was 2.67% for free recall and 4.75% for directed right. The LEA was 2.25% for directed left. These results are also consistent with previous results from Roup et al. suggesting that the free recall response condition result in an REA, directed right response conditions result in an even stronger REA, and that directed left response conditions result in an LEA (Roup et al., 2006).

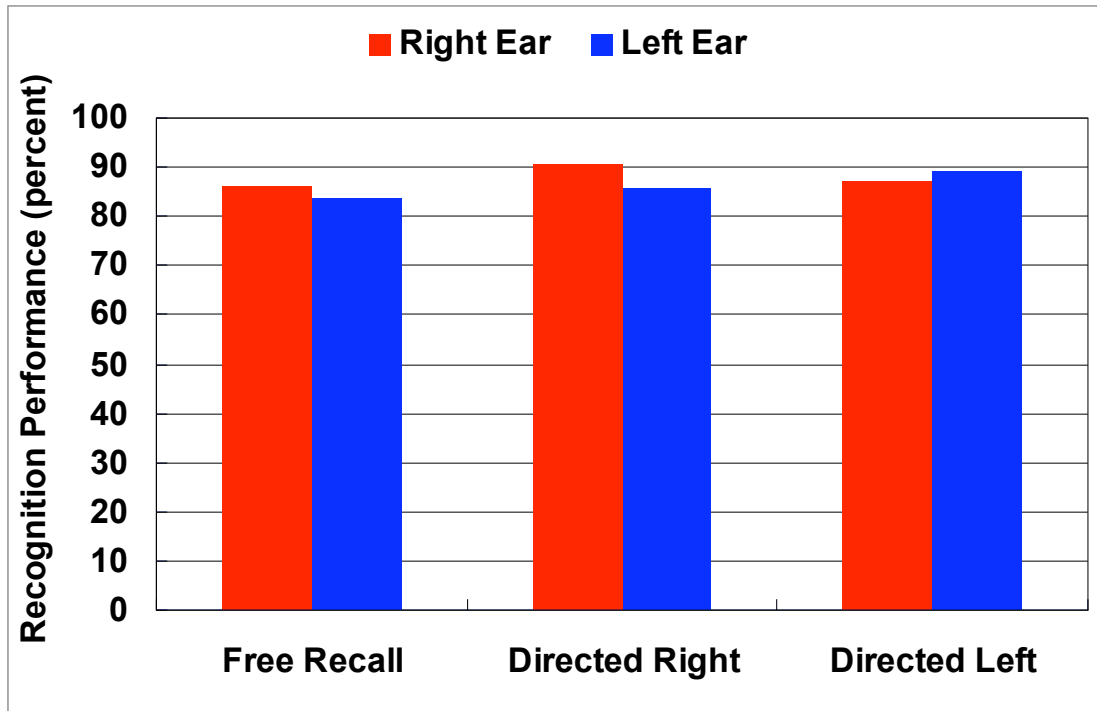


Figure 1. Mean dichotic word recognition scores (in percent correct) for the right ear and left ear across the three response conditions: free recall, directed right and directed left.

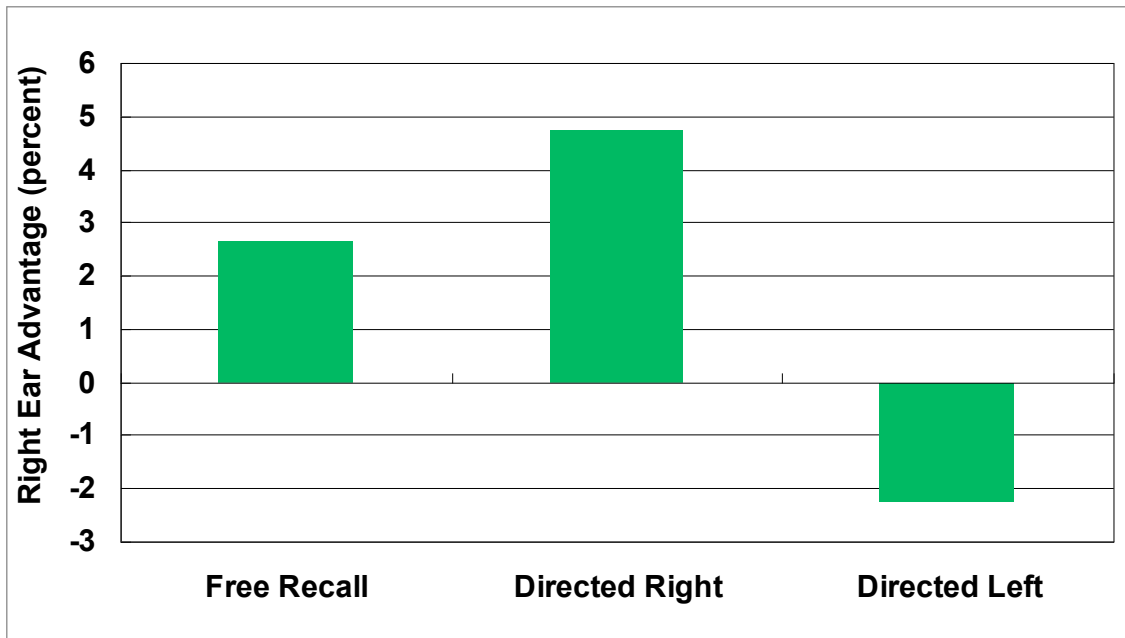


Figure 2. Mean ear advantages (in percent correct) across response conditions: free recall, directed right and directed left. A positive ear advantage refers to a REA whereas a negative ear advantage refers to a LEA.

Statistical Analysis

Before statistical analysis, the dichotic word recognition percentage scores were transformed to a rationalized arcsine to avoid the error in variance associated with percentage data (Studebaker, 1985). The transformed data were subjected to a series of *t*-tests of means in order to compare the data for overall performance and ear advantage across conditions. Results from the *t*-test comparing overall performance across conditions revealed that mean overall performance in the directed right condition was significantly better than mean overall performance in the free recall condition ($t_{11} = -6.41$; $p < .05$). Similarly, the mean overall performance in the directed left condition was significantly better than mean overall performance in the free recall condition ($t_{11} = -5.65$; $p < .05$). Mean overall performances between the directed right and directed left conditions were not significantly different ($t_{11} = 0.20$; $p > .05$).

The transformed data were also subjected to a *t*-test comparing ear advantage across conditions. Results revealed that mean ear advantages between the free recall and directed right conditions were not significantly different ($t_{11} = -1.20$; $p > .05$). The mean ear advantage in the free recall condition was significantly greater than the mean ear advantage in the directed left condition ($t_{11} = 2.59$; $p < .05$). Similarly, the mean ear advantage in the directed right condition was significantly greater than the mean ear advantage in the directed left condition ($t_{11} = 2.68$; $p < .05$).

Table 1 presents the means and standard deviations of dichotic word recognition performance across the three response conditions for both the NAM

pairings and original pairings data (Roup et al., 2006). In order to compare the data of words paired by standards of the NAM and previous data of original word pairings (i.e., Roup et al., 2006) for overall performance and ear advantage across conditions, the data were subjected to a one-way analysis of variance (ANOVA). No significant differences were observed between the NAM pairings and original pairings data for overall performance and ear advantage across conditions. When word pairs are created for dichotic listening, results from young adults' overall performances and ear advantages show insignificant differences between using pairs created according to categories of lexical difficulty as stimuli and using older original pairings as stimuli.

Table 1. Means and standard deviations of data from both the NAM word pairings and the original word pairings (i.e., Roup et al., 2006) for dichotic word recognition performance across the three response conditions: free recall, directed right, and directed left.

	Right Ear (%)	Left Ear (%)	RE – LE (%)
<i>Present Study</i>			
Free Recall	86.3	83.6	2.7
Mean	4.8	5.0	5.2
SD			
Directed Right			
Mean	90.6	85.8	4.8
SD	3.1	6.0	5.2
Directed Left			
Mean	87.0	89.3	-2.3
SD	5.9	3.1	5.7
<i>Roup et al., 2006</i>			
Free Recall			
Mean	86.9	84.4	2.5
SD	7.6	7.4	7.6
Directed Right			
Mean	91.3	84.6	6.7
SD	6.9	9.1	5.1
Directed Left			
Mean	86.4	89.9	-3.6
SD	9.2	6.0	7.2

CHAPTER 4

DISCUSSION

The present study investigated if changes in lexical information based on the Neighborhood Activation Model affected dichotic word recognition performance in young adults with normal hearing. Mean dichotic word recognition scores for the right ear and left ear across response conditions suggest that dichotic word recognition scores improve when the listener's response is directed because the right ear had the best mean word recognition score for the directed right condition and the left ear had the best mean word recognition score for the directed left condition (Roup et al., 2006). Both ears had the lowest mean word recognition score for free response. These results were expected and are consistent with previous results (i.e., Roup et al., 2006).

Mean ear advantages across response conditions show that the free recall and directed right response conditions result in a REA while the directed left response condition results in a LEA. These results were also expected and consistent with previous results from Roup et al., suggesting that the free recall response conditions result in an REA, directed right response conditions result in an even stronger REA, and that directed left response conditions result in an LEA (Roup et al., 2006).

When mean word recognition scores across response conditions for each of the four categories of lexical difficulty according to the NAM (high density and high frequency, high density and low frequency, low density and high frequency, and low density and low frequency) were compared, no significant differences

were observed between any of the four categories. The mean word recognition scores for each category of lexical difficulty resembled the same distribution across response conditions as the mean scores for overall performance. Additionally, comparisons made between data of the present study (i.e., word paired according to the NAM) and previous data of original word pairings (i.e., Roup et al., 2006) revealed no significant differences in performance. These results likely reflect two important factors of the present study: 1) subjects recruited for the present study exhibited near ceiling performance, and 2) the NAM categories of lexical difficulty were held consistent between ears.

Listeners involved in the present study were young adults with normal hearing, and so were naturally very good at the dichotic listening tasks presented to them. Changes in lexical information within dichotic word pairings had little impact on the already excellent dichotic listening skills of the recruited subjects. The subjects' near ceiling performance is evident in Figure 3, which displays individual subject data points across response conditions. The data points in Figure 3 are clumped closely together and positioned very near the ceiling of recognition performance. In 2001, a similar study revealed significant differences in overall word recognition performance between categories of lexical difficulty (Carter & Wilson, 2001). This previous study presented to the listeners not only dichotic word pairs with words from the same lexical difficulty category but also dichotic word pairs with words from different categories of lexical difficulty (Carter & Wilson, 2001). Word pairs including two lexically "easy" words or two lexically "hard" words in this previous study revealed similar word recognition

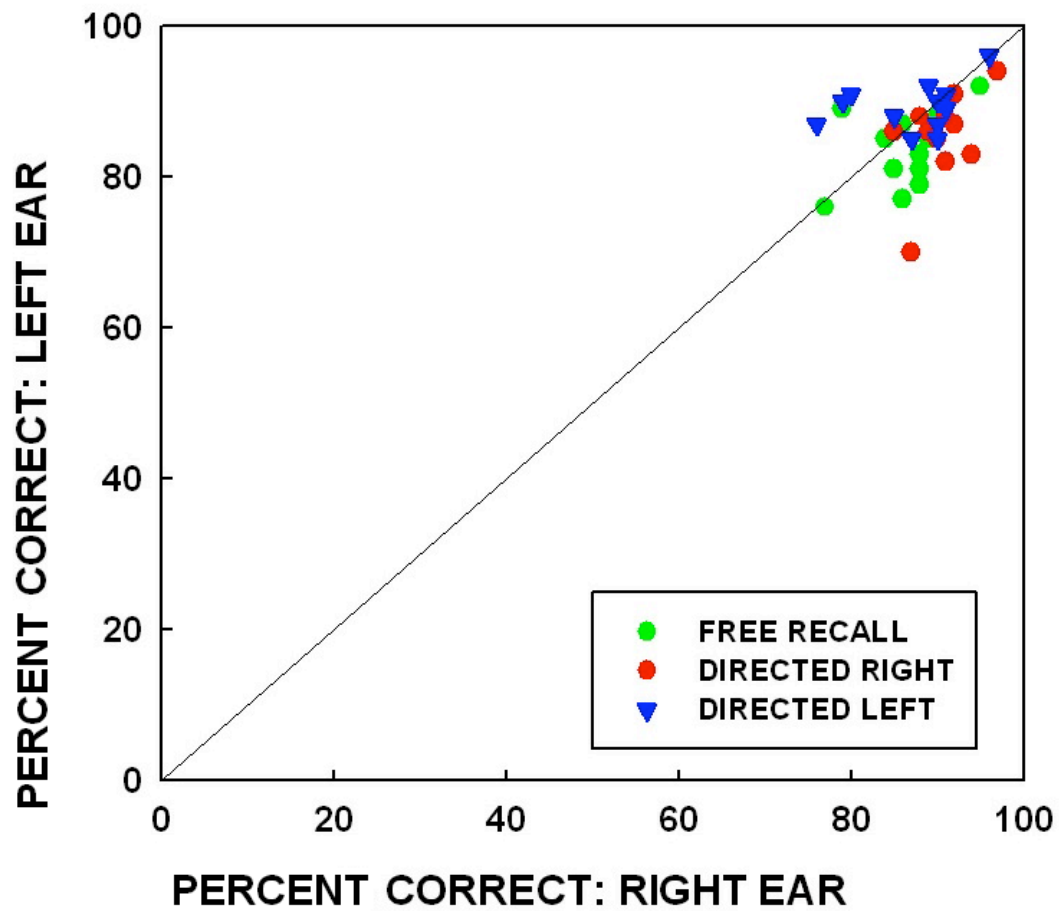


Figure 3: Bivariate plot of recognition performance for the right ear on the abscissa and recognition performance for the left ear on the ordinate. Data points above the line indicate a LEA and points below the line indicate a REA. Data points on the line indicate equal performance between ears.

performance results to what was found in the present study (Carter & Wilson, 2001). However, Carter and Wilson found that presenting word pairs including words from different lexical difficulty categories (i.e., “hard-easy” or “easy-hard”) revealed a difference in word recognition performance in young adults (Carter & Wilson, 2001). Results from this previous study revealed that lexically “easy” words were recognized more accurately than lexically “hard” words, regardless of the ear to which they were presented (Carter & Wilson, 2001). Therefore, young adults in this previous study ended up with a REA when “easy” words were presented to the right ear, and a LEA when “easy” words were presented to the left ear (Carter & Wilson, 2001). The present study presented dichotic word pairs to listeners that included words from the same category of lexical difficulty within each pair. This difference between studies of the way words were paired together may influence the presence of significant differences in results between lexical categories.

Words paired dichotically to ensure lexical consistency according to the NAM resulted in typical patterns of performance associated with dichotic speech recognition tasks in young adult listeners with normal hearing. While no significant differences were observed in recognition performance scores between categories of lexical difficulty, lexical consistency in dichotic stimulus pairings may improve dichotic test stability for listeners with hearing loss and potential auditory processing disorders – referring to listeners with word recognition performance well below ceiling. Future research is planned to measure dichotic

word recognition with word pairings from different NAM lexical categories in order to assess the affect on word recognition performance and the REA.

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